INVESTIGATIONS ON STOMATA AND STOMATAL CLUSTERS IN BEGONIA:

A Possible Stomatal Indicator of Tropical Seasonal Climate Change

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ABSTRACT

An initial investigation of stomatal length and leaf age in a population of Begonia nelumbiifolia Cham. and Schlect. from northeastern Hidalgo, Mexico suggests stomatal length may be an indicator of seasonal climatic change. At five sample sites, adult leaves have medium sized stomata, and young leaves have the smallest stomata.

Several ecological and climatic factors appear to causally affect stomatal size in this Hidalgo B. nelumbiifolia population. These factors include: 1) the life zone category at the Hidalgo site is considered tropical premontane wet forest and one distinguishing characteristic of this life zone is a semi-deciduous canopy, thus reflecting a distinct dry season; 2) at the upper elevation limit in the B. nelumbiifolia population, the premontane wet forest graduates into pine/oak forest, suggesting ecotone type habitat conditions may prevail through the population; 3) the northernmost limit of any tropical rainforest life zone in the New World tropics is within about 75 kms of this Hidalgo B. nelumbiifolia population, further implying the possibility of unusual ecological and climatic conditions.

INTRODUCTION

In recent years several reports describe morphological indicators of climatic or environmental change. Some examples include the following: oxygen-isotope ratios in trees reflect annual temperature and humidity values (Burk and Stuiver 1981). Chondrites, a trace fossil of possible nematode affinity, indicates the presence of anoxia in sediments (Bromley and Ekdale 1984). Paleoclimatological studies concerning leaf physiognomy reflect microclimatic conditions under which the plants grew (Davis and Taylor 1980). The annual growth patterns in the bivalve mollusk Spisula solidissima record temperature variations in marine waters (Jones 1981); and possibly the most widely recognized method for indicating climate variations is dendochronology (Stokes and Smiley 1968; and Fritts 1976).

Stomatal size and density are characters within species known to vary significantly depending upon environmental conditions (Meidner and Mansfield 1968 and Zeiger et al. 1987). Increased stomatal density and reduced guard cell length are reported to accompany xerophytic Israelian trees

(Gindel 1969). Populations of Danthonia sericea, growing on dry, sandy, upland sites in the New Jersey Pine Barrens are known to have a higher stomatal frequency than populations growing in low, boggy areas (Clay and Quinn 1978). When Kalenchoe fedschenkoi was subjected to different experimentally designed habitats, stomatal frequency was reported to be lowest under humid conditions (Sharma and Dunn 1968). Frequency of single stomata, stomatal density, and stomatal length in B. nelumbiifolia were characters correlated with elevation in samplings from various areas of tropical forest in Mexico (Hoover 1986).

In this paper, data are presented suggesting that stomatal size in Begonia nelumbiifolia varies with tropical seasonal climate changes and thus may serve as a morphological indicator of such seasonal changes. This conclusion is based on a statistical analysis between leaf age and stomata length in population samples along an elevational gradient in Hidalgo, Mexico.

SAMPLE SITES AND METHODS

In October 1979, a large population of B. nelumbiifolia was located on steep embankments and cliffs above the highway between Chapulhuacan and Jacala, in the state of Hidalgo (Fig. 1), an area from which numerous herbarium specimens have been collected (Burt-Utley 1985). Five sites from the B. nelumbiifolia population were sampled at different elevations, 1080 m, 990 m, 839 m, 704 m, and 420 m; these sample sites respectively are referred to as TM1 - TM5.

The vegetation zone for samples TM1 - TM5 in Hidalgo is Bosque Mesofolio de Montana, according to Rzedowski's 1978 system of classification. In Holdridge's et al. (1971) system of classification, the sample sites would be Tropical Premontane Wet Forest, based on general observations of the canopy, ground layer, and density of epiphytes within the forest. Of importance is the observation that several kms past TM1 the Premontane Wet Forest grades into pine and oak forest, or in Rzedowski's (1978) terminology, Bosque Coniferas et Quercus.

In the field, three healthy individual plants from similar microhabitats were selected for sampling at each site. Three leaves from each plant were chosen and the leaves were determined by the position on the rhizome to be old, adult (recently mature) and young (developing). From each individual leaf three areas were selected for sampling, one each from the apex, mid-section and basal area. The sampling procedure involved painting colorless Revlon fingernail polish on a 50 mm^2 area of the lower surface for each of the described locations, waiting for the epidermal peel to dry, then removing it with forceps. From each sample site 27 epidermal peels were collected; thus, 135 peels for all sites. Using the position method for distinguishing between different leaf ages provided a

degree of standardization, though tagging individual plants and observing them over a period of several years is preferable, but lacks practicality for an initial inquiry; the author felt the best approach was first to determine if any generalized trends were apparent in the data. It should be noted that Reich and Borchert (1988), in their study of stomatal function and leaf age in several tropical trees, employed two methods for sampling tree leaves: one method was based on the different times when individual trees flushed, and the other method involved sampling trees that retained several flushes, which is similar to the method employed in this study. Epidermal peels were analyzed in the laboratory using an Edmund Scientific Microprojector. A screen was placed in front of the projector at a measured distance, stomata length measurements were made in millimeters, and converted to microns. Fifteen stomatal measurements per epidermal peel were made. All data were entered into the Harvard University Science Center computer. The specific statistical test utilized, an F-test of Variation, was carried out on this machine using the Minitab program.

RESULTS AND DISCUSSION

B. nelumbiifolia is a herbaceous perennial with a creeping, rhizome-like stem, and every year drops several leaves. This species has one of the widest geographical distributions of any species in the Section Gireoudia, to which it is assigned, and ranges from Mexico to Colombia, though has not been collected in Honduras or Nicaragua (Burt-Utley 1985, Smith and Schubert 1946). The occurrence of B. nelumbiifolia in Hidalgo and adjacent San Luis Potosi represents the northern geographical range of the species as it is presently reported (Burt-Utley 1985).

The F-tests for determining variation among leaf ages and stomatal size at each site indicate high degrees of significance (Fig. 2).

At the five sample sites for this Hidalgo population of B. nelumbiifolia the old leaves have the largest stomata, while adult leaves indicate moderate sized stomata at four sites, with young leaves having the smallest sized stomata at four sites also (Fig. 2). The exception to the trend is found between the adult and young leaves at site TM2, where the young leaves exhibit larger stomata than do the adult leaves.

Several factors may be suggested to explain this observed stomatal size variation with leaf age. Premontane wet forest is characterized by a semi-deciduous canopy, which indicates the presence of a distinct wet and dry season (Holdridge et al. 1971). The onset of dry seasonal conditions in the tropics causes varied response from organisms: fewer insects are flying, less activity of decomposers on the forest floor, fewer birds and mammals breeding, and, of course, particular species of trees shedding their leaves. Many plant species indicate specific phenological rhythms in response to the climatic conditions brought on by the dry season (Leigh et al. 1980). Thus, it is possible that B. nelumbiifolia exhibits a rhythmic variation in stomatal size in response to these climatic variations. Other

species of Begonia in the section Gireoudia indicate an increased thickening of the hypoderm in response to the onset of the dry season, which may serve the temporary function of storing water (Burt-Utley 1985). Also, the pine and oak forest several kms past TM1 suggests the possibility of an ecotone type habitat where environmental conditions from both forest types overlap. The effect of ecotone habitat conditions would not likely be limited to just sample site TM1, but could extend for several kms into both forest types and thus would affect other sample sites as well. Ecotone conditions may further exaggerate the effect of a dry season and dramatically affect stomatal size in B. nelumbiifolia. The stomata on leaves developing during the rainy season may be consistently different in size compared to stomata developing during the dry season, and likewise stomata developing during the transition of seasons may exhibit a distinct size variation as well.

According to Rzedowski's map (1981), the Bosque Mesofolio de Montana of northeastern Mexico extends as a thin strip through Hidalgo and terminates about 75 kms past Chapulhuacan at a latitude of 22°N. Samples TM1 - TM5 were collected between 21°N and 21°20'N latitude, which is about 40' from the northernmost limit of this forest type in the New World tropics. Considering this population of B. nelumbiifolia is found so far north may further assist in explaining stomatal size variation with leaf age. This rainforest may experience more variable climatic fluxes than tropical forests of a similar type further south. These B. nelumbiifolia data suggest a stomatal indicator of tropical climate variation in Hidalgo and it will be interesting to determine if such a morphological character has applicability throughout other regions of the tropics.

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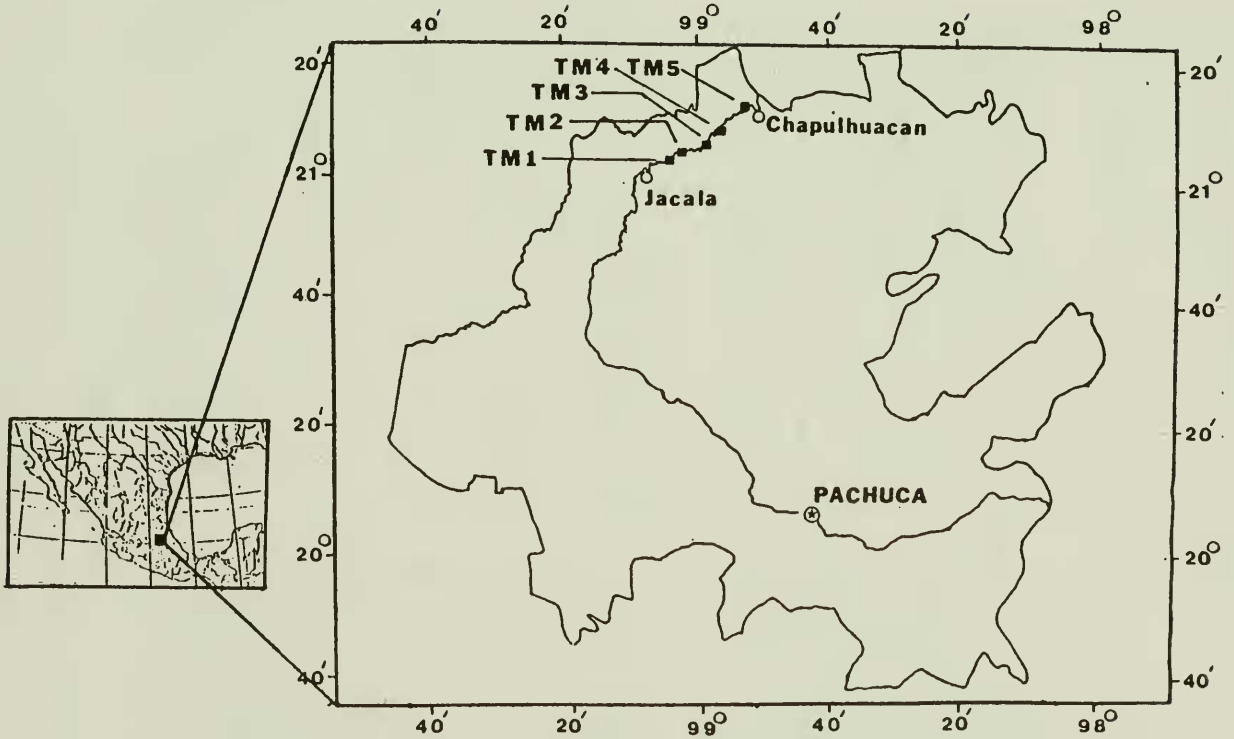

Fig. 1 - Geographical locations of B. nelumbiifolia sample sites in Hidalgo, Mexico.

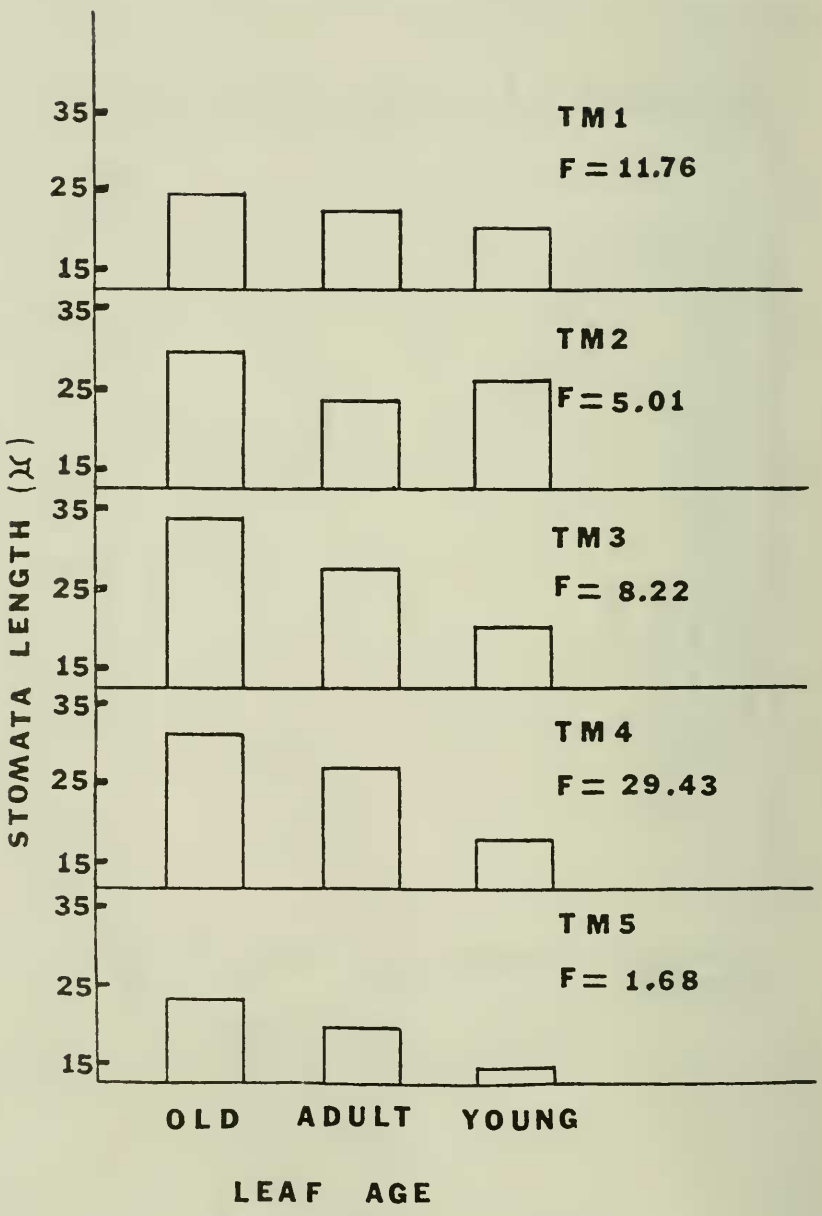

Fig. 2 - Stomata length and leaf age analysis in *B. nelumbiifolia* population samples.